# THE DISTRIBUTION AND ECOLOGY OF TWO KINOSTERNID TURTLES IN IOWA

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An abstract of a Thesis by

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Over 4 years of study have shown that little, if any, shift occurs in the habitat preferences or behavior of Illinois mud turtles and stinkpot turtles in Iowa, at the extreme edge of the species' ranges. The mud turtle is restricted in Iowa to ephemeral ponds associated with Sparta sand or Chelsea loamy fine sand. The stinkpot is restricted to permanent water with Colo silty clay loam, aquolls, Ankeny sandy loam or other alluvial soils. While stinkpots will use ephemeral pools, permanent water must be nearby. Although mud turtles may occasionally be found in permanent bodies of water, we suspect that this condition is probably transient, with ephemeral pools probably a requirement to limit competing species.

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# INTRODUCTION

The Illinois mud turtle, *Kinosternon flavescens spooneri* and the stinkpot turtle, *Sternotherus odoratus* are two species of the family Kinosternidae found in eastern Iowa at the extemes of their ranges. They are of particular interest to Iowa because both are rare in the state. In the more central parts of their ranges they exhibit similarities and differences that may or may not be expressed under the environmental stresses often present at the limits of species' distribution. This study examines certain features of the niches of these species in Iowa and compares them to what is known about these turtles elsewhere. In so doing, it distinguishes the niches of the species in Iowa.

## Taxonomic Relationships and Distribution

Iowa is home to thirteen species of turtles, encompassing four families: Chelydridae, Kinosternidae, Emydidae, and Trionychidae. The kinosternid group is represented by two species, *Kinosternon flavescens* (yellow mud turtle) and *Sternotherus odoratus* (stinkpot). *Kinosternon flavescens spooneri* is a northern subspecies whose status has been controversial (see Christiansen and Iverson, 1993). It is found in isolated, relict populations in sandy areas of western Illinois, northeastern Missouri and extreme southeastern Iowa (Bickham et al., 1984). The nominate subspecies, *Kinosternon flavescens flavescens* is found in Mexico and the southwestern United States as far north as Nebraska (see Fig. 1). Two other subspecies, *K. f. arizonense* and *K. f. durangoense*, occur in Mexico and southern Arizona (Iverson, 1979). Of the kinosternid group, *Kinosternon flavescens* is the westernmost and most aridity-adapted representative.

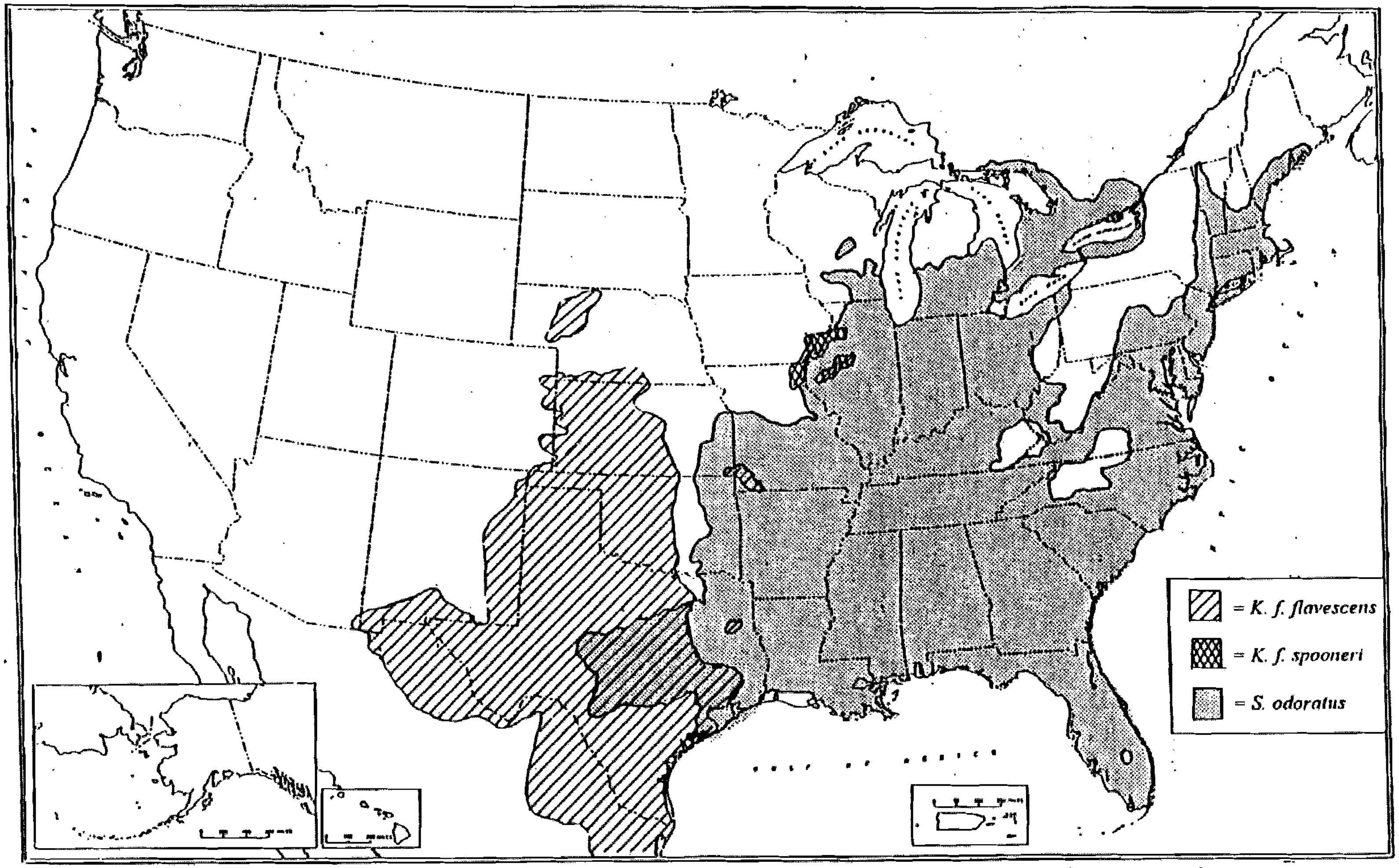


**Figure 1.** North American distribution of *Sternotherus odoratus*, *Kinosternon flavescens flavescens* and *Kinosternon flavescens spooneri* (from Conant and Collins, 1991).

The family Kinosternidae, the mud and musk turtles, is represented by eight species in the United States, the majority existing in the southeast. When disturbed, members of the family release a musky secretion from two glands associated with the plastral bridge. The musk turtles (*Sternotherus*) have a relatively small plastron with a moveable anterior lobe. The mud turtles (*Kinosternon*) possess a much larger plastron with mobility of both the anterior and posterior lobes.

*Sternotherus odoratus* is the most widely distributed of all the kinosternid turtles in North America, occurring from southern Ontario to southern Florida, westward into eastern Iowa and central Texas (Fig. 1, Conant and Collins, 1991). It is the only member of the musk turtle group (*Sternotherus*) occuring north of Kentucky (Fig. 1). In Iowa, stinkpots are restricted to the extreme eastern edge of the state.

Stinkpots were first reported from Iowa in June 1955, in Muscatine county by Dodge (1956). Since that record, specimens have been collected from several localities in Muscatine county, and one in Johnson county have been deposited in the Drake University research collection. Little is reported of the distribution or ecology of stinkpots in the state. After the discovery of *Kinosternon flavescens spooneri* in Muscatine county (Dodge, 1956), other *K. f. spooneri* populations were found in Louisa, Des Moines and Lee counties (Christiansen et al., 1990). The largest extant population is located at Big Sand Mound Nature Preserve in Muscatine and Louisa counties. The Illinois mud turtle has been extensively studied in Iowa (Bickham et al., 1984, Cooper, 1975; Christiansen and Gallaway, 1984; Christiansen et al., 1985, 1990; Christiansen and Bickham, 1989). The distribution of collected specimens of both species suggested that the two taxa were sympatric in Louisa and Muscatine counties, especially in the valleys of the Cedar and Iowa Rivers.

**Habitat and Behavior of Stinkpots**

Habitat preferences for stinkpots have been characterized by many researchers, and include almost any waterway with a slow current and soft bottom: rivers, streams, lakes, ponds, sloughs, canals, swamps, bayous and oxbows (Ernst and Barbour, 1982). Vogt (1981) notes that they avoid temporary ponds, gravel or rock bottoms, and fast-moving rivers. Stinkpots are extremely aquatic turtles, and while some researchers state that they never bask out of the water (Carr, 1952), in the northern U.S., some have been observed resting on logs and over-hanging trees up to two meters above the water (Risley, 1933). In most cases, the turtles seem to bask just beneath the water surface, supported by submerged vegetation or structure (Ernst, 1986). Stinkpots are often observed walking on the bottom in search of food, and in the southern U.S, seem to show crepuscular activity cycles (Mahmoud, 1969) that may be absent from northern populations (Vogt, 1981). Ernst (1986) found feeding to begin in spring when water temperatures reached 18°C, which was almost four degrees higher than the initial feeding temperatures of other aquatic turtles at his southeastern Pennsylvania study site. Diet is omnivorous throughout its range, consisting largely of mollusks (snails and clams) and aquatic insects. Carrion, fish, worms, tadpoles, frogs, and plants form the remainder of the diet (Risley, 1933; Lagler, 1943; Mahmoud, 1968; Ernst, 1986). Juveniles (<5 cm carapace length) feed predominantly on small aquatic insects, algae and carrion (Ernst and Barbour, 1989).

Stinkpots generally hibernate buried to a depth of 15-30 cm into the mud bottom of their aquatic habitat. They have also been found burrowed under logs, rocks or trash in or near the water, and in recesses beneath banks, or in muskrat dens or lodges (Ernst and Barbour, 1989). They begin to burrow when the water temperature falls below 10° C, but observers in several northern locations have noted activity late into the fall: as late as October in Ohio, and in Indiana, turtles were seen walking beneath the ice on 31 December (Everman and Clark, 1916).

Consistent with their aquatic life-style, stinkpots mate in shallow water, at night or early in the morning (Ernst and Barbour, 1989). Copulation takes place in both spring and fall (Everman and Clark, 1916; Risley, 1938; Lagler, 1941). The nesting season varies with latitude, from March through July in the southern U.S., May through August in the northern parts of the range (Ernst and Barbour, 1989). Female stinkpots are noted for sharing their nests, which have variable characteristics. Most nests are shallow, up to 10 cm deep, and flask-shaped (Ernst, 1986). The turtles dig them with their hind feet, scraping away debris such as soil, decaying vegetable matter, leaf mold, or rotting wood. Nests have been found as far as 50 meters from the water (Ernst and Barbour, 1989). Eggs have also been found on open ground, under stumps and fallen logs as well as in muskrat lodges and duck blinds (Ernst and Barbour, 1989). Stinkpot eggs are ovoid, with a thick, white, brittle shell that protects the developing embryo from dehydration. Hatchlings may enter the water immediately after emerging from the egg, or may overwinter in the nest to enter the water the following spring (Gibbons, 1978).

**Habitat and Behavior of Mud Turtles**

*Kinosternon flavescens* probably colonized Iowa during the Hypsithermal period, an arid portion of the Holocene stage of the Pleistocene epoch that occurred 4,000 to 8,000 years B.P. (Christiansen et al., 1985). At that time Iowa possessed a warmer, drier climate (Prior, 1991) that supported colonization by many desert-adapted species from the Southwest. Subsequent return to a cooler, wetter period forced the species into its current range, leaving behind a few relict midwestern populations

(Christiansen et al., 1985). In 1951, Smith recognized the evolutionary divergence of the Illinois population in describing *Kinosternon flavescens spooneri*.

The habitat for this race is xeric with a sand substrate, and is little different than that of its nominate subspecies, the yellow mud turtle (Christiansen et al., 1985). In Oklahoma, the yellow mud turtle is found in temporary ponds in dry, sandy prairie areas (Mahmoud, 1969). Further west in New Mexico and Texas it often inhabits cattle watering tanks (Christiansen and Dunham, 1972). Smith (1961) found the Illinois mud turtle in sandy areas along the Illinois River and thought it might be common in sand prairie ponds and sloughs throughout the upper Mississippi River valley. Cahn (1937) describes it as primarily a pond turtle. The largest known population of Illinois mud turtles occurs in Iowa at Big Sand Mound (Fig. 3), in association with such xeric-adapted species as the ornate box turtle (*Terrepene ornata*), the western hognose snake (*Heterodon nasicus*), and the plains pocket mouse (*Perognathus flavescens*) (Cooper, 1975).

Cooper (1975) and Christiansen et al. (1985) studied the behavior of Illinois mud turtles at Big Sand Mound and found them in temporary and permanent waters that contained varying amounts of vegetation and debris. Pond bottoms varied from soft, organic mud-sand to packed sand with no anchored vegetation. Webster (1986) found *K. f. flavescens* tolerant of either sandy loam or muddy substrates, with vegetation ranging from absent to abundant.

In Iowa, most turtles were active for about 90 days. This is the shortest annual activity cycle known for any turtle (Christiansen et al., 1985). During this time, feeding activity occured for only 70 days (Cooper, 1975). Mud turtles aestivate (Seidel, 1978) during the hottest part of the summer in burrows they have dug into the sand. They often remain there, inactive until the following spring (Christiansen et al, 1985; Iverson, 1991), thus spending most of the year on land. Activities that occured in the water, such as feeding, took place at all hours of the day (Cooper, 1975). Both the Illinois mud turtle and the yellow mud turtle seem to exhibit a photophobic tendency that increases as the summer progresses, and like stinkpots tend to become increasingly crepuscular. They bask out of water only rarely, preferring, like stinkpots, to rest just under the surface of the water.

Cooper analyzed the stomach contents of 47 Illinois mud turtles and found their diet to consist primarily of insects and fish, with crustaceans, plant debris and mollusks comprising the remainder. When fish were absent from feeding pools, the diet shifted primarily to snails, insects and vegetation, similar to that of the stinkpot (Christiansen et al., 1985).

Mating of Illinois mud turtles was observed by Cooper (1975) to occur from May to July, in or near water, and always in the morning. Nesting occurred in the late afternoon, with several burrows being dug in the sand before ovipositing actually occurred. Nest burrows were generally within 30 meters of the water, in areas of scattered vegetation, and dug 12 to 14 cm deep into the sand. Nesting took place in June and early July at Big Sand Mound, with eggs hatching in September. Hatchlings did not emerge from the nest in the fall in Iowa, but generally spent the winter in the nest, emerging from late April to mid-June (Christiansen and Gallaway, 1984).

Throughout most of their range in North America, stinkpots occupy an environment that is much more aquatic than that of mud turtles (Cahn, 1937; Cook, 1984; Ernst and Barbour, 1982; Mahmoud, 1969; Vogt, 1981). Iowa is at the northwestern edge of the stinkpot's range, and the extreme northeastern edge of the mud turtle's range. Similaries seem to exist between these species in Iowa; both inhabit ponds and share a preference for mud or sand-mud substrates. Early studies by

Christiansen (personal commmunication) showed both turtles to be found only where sandy soil exists adjacent to ponds. In addition, mollusks and insects may form the bulk of the diet for each species. These similarities suggest that in Iowa these turtles occupy overlapping niches within the same river systems, to the point that there may be competetive exclusion.

In addition to comparing the niches for these two taxa with those for the species outside of Iowa, the present study proposes to gain additional information on the distribution of each of these rare species in Iowa, to learn whether they coexist in the same bodies of water, and to determine whether there are any features of their niches in Iowa that might prevent their direct competition.

# MATERIALS AND METHODS

This study was conducted from May, 1989 through June, 1992. Field work occurred from May through July in 1989, May and June of 1990, May through July of 1991, and June and July of 1992 for a total of 312 trap-days. One trap per day equals one trap-day. Water temperatures in Iowa are generally too cool to support *Kinosternon* or *Sternotherus* activity prior to the month of May and mud turtle activity generally ceases by mid-July in the state (Mahmoud, 1969; Christiansen et al., 1985).

Distributional and ecological data were compiled from specimens and records in the research collection of Drake University as well as from published information. All Iowa turtle specimens collected in this study can be found in the Drake University research collection except for a single specimen of *S. odoratus* located in the Iowa State University collection and the specimens of *K. flavescens* and *S. odoratus* reported by Dodge and Miller ( 1955) and Dodge (1956).

Turtles were collected primarily in modified fike net traps (Legler, 1960), but were also taken by hand in walking surveys. Collections were made under Iowa collecting permit #SC-00210-01. Traps were baited with fresh fish in screen baitholders and placed in suitable locations (near basking logs, log jams or sand bars) at the survey sites. Traps were generally set in the afternoon and checked the next morning. Maps were drawn of the trapping sites and characterisitcs of the habitat were recorded. Journal notes were maintained for all turtles captured. The infomation recorded included species of turtle, its sex, unusual characteristics and features of the location where it was captured. Some specimens, usually one of each species, of all turtles captured were retained. The balance were released at the place of capture. The traps were usually moved to new locations each day, although when it was believed the location was inadequately sampled, they were re-baited and left for additional nights.

Turtles to be preserved were killed by cephalic injection of 70% ethanol. The shell and soft parts method of preparation (Christiansen and Dunham, 1972) was used in which the skin and gonads were tagged separately, fixed in 13% formalin and stored in 5% formalin (Christiansen and Dunham, 1972). The skeleton and undamaged shell were scraped clean and stored dry. All voucher specimens were tagged and placed in the Drake research collection for further study.

U.S. Geological Survey 7.5 minute topographic maps were used to locate possible sampling sites in Muscatine, Louisa, Johnson, Des Moines and Lee counties. Sites on private land were visited with the landowner's permission. Traps were placed in quiet water from shore or by canoe. Trapping sites were chosen from Interstate 80 south to the Iowa River, and east to the Mississippi River. Although it was intended that all suitable locations for turtles would be trapped, certain factors made this impractical. Some potential trapping sites were located in the floodplain of the Cedar and Iowa Rivers, however flooding in 1990 and 1991 limited access to some of these areas. Attempts were made to visit these areas at other times, but the short activity season for Illinois mud turtles makes it fruitless to continue the study after mid-July of any year. In other years (1989 and 1992), dry conditions made it impossible to find water deep enough to place turtle traps in many places. Several areas along the Iowa River in Louisa county, were judged to be too public to safely leave the traps.

Upon completion of the field work, all sites where either mud turtles or stinkpots were found in Iowa were plotted on county soil survey maps compiled by the Soil Conservation Service of the United States Department of Agriculture. Soil types were compared by listing soil types at each capture point for each turtle species.

**Description of the study area**

The present study took place in Iowa in Muscatine, Louisa, Des Moines, and Lee counties (Fig. 2). Major emphasis was placed on the first two counties, Muscatine and Louisa. Areas of concentration within those counties were Big Sand Mound Preserve, Cone Marsh State Management Area, Pike Creek, Cone Lake, the entire length of the Iowa River as it traverses Louisa county, and the Cedar River as it passes through Muscatine county (Fig. 3). Trapping along these rivers took place mainly in quiet backwaters, sloughs and floodplain pools adjacent to the rivers.

The sites of the present study are located in extreme southeastern portion of Iowa, within a unique area described geologically as the Mississippi River Alluvial Plain (Prior, 1991). It extends from Lee county northward along the Mississippi River to Davenport, and inland to include portions of the drainages of the Cedar and Iowa Rivers (Fig. 4). These low-lying level areas are adjacent to rivers, and are often flooded in spring. They are poorly drained and contain marshes, backwater sloughs, ephemeral pools, and lowland timber. Sand dunes are a prominent feature of the Mississippi Alluvial Plain, appearing along terrace edges, the result of alluvial deposits that are exposed by low water, then blown by wind. Big Sand Mound is one of the few areas of relatively active dune fields remaining in the area; many other dunes are stabilized by vegetation or crops.

The lowland area between the Cedar and Iowa Rivers, above their confluence, is known geologically as the Lake Calvin Basin. Part of the Alluvial Plain, it is similarly characterized by broad floodplains and terraces, clearly defined valley walls, and sand dunes underlain by a thick accumulation of water-sorted sediments (Prior, 1991).

Much of the exploration was centered along Pike Creek, a permanently flowing tributary of the Cedar River contained entirely within the Lake Calvin Basin area. It

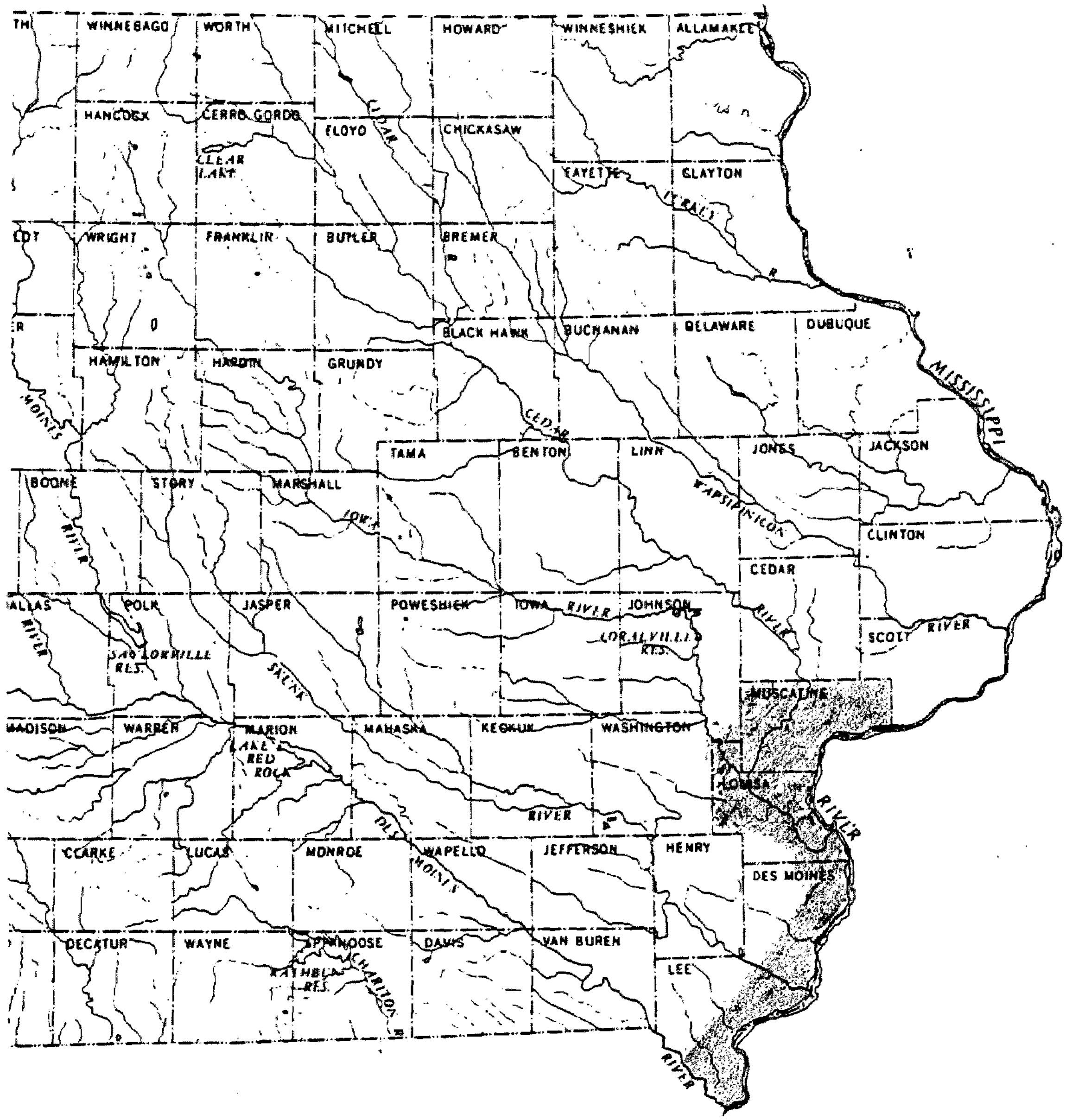


**Figure 2.** Muscatine, Louisa, Johnson, Des Moines and Lee counties (shaded area) comprise the study area. Map is a portion of Iowa.

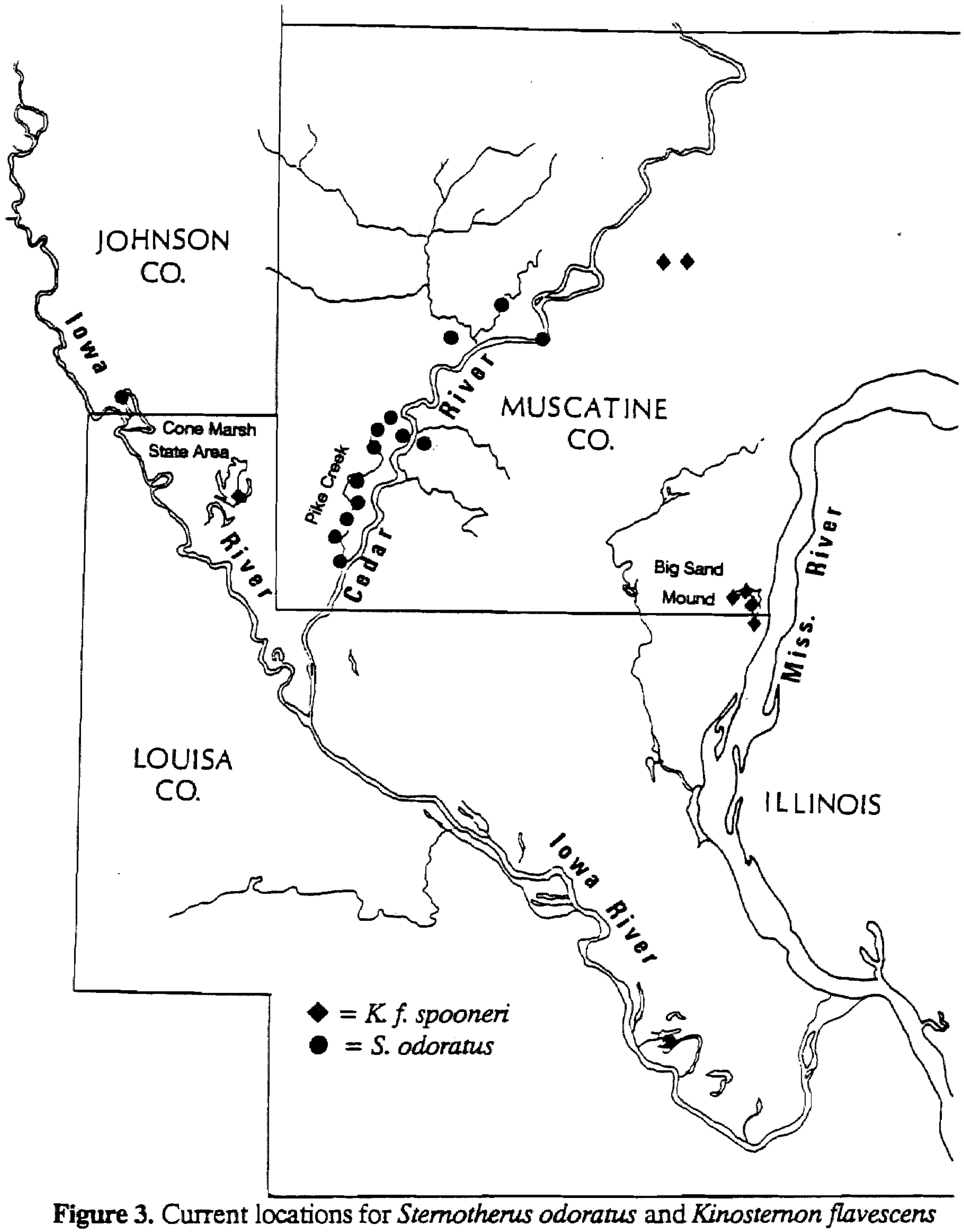


**Figure 3.** Current locations for *Sternotherus odoratus* and *Kinosternon flavescens spooneri* in Muscatine, Louisa and Johnston counties.

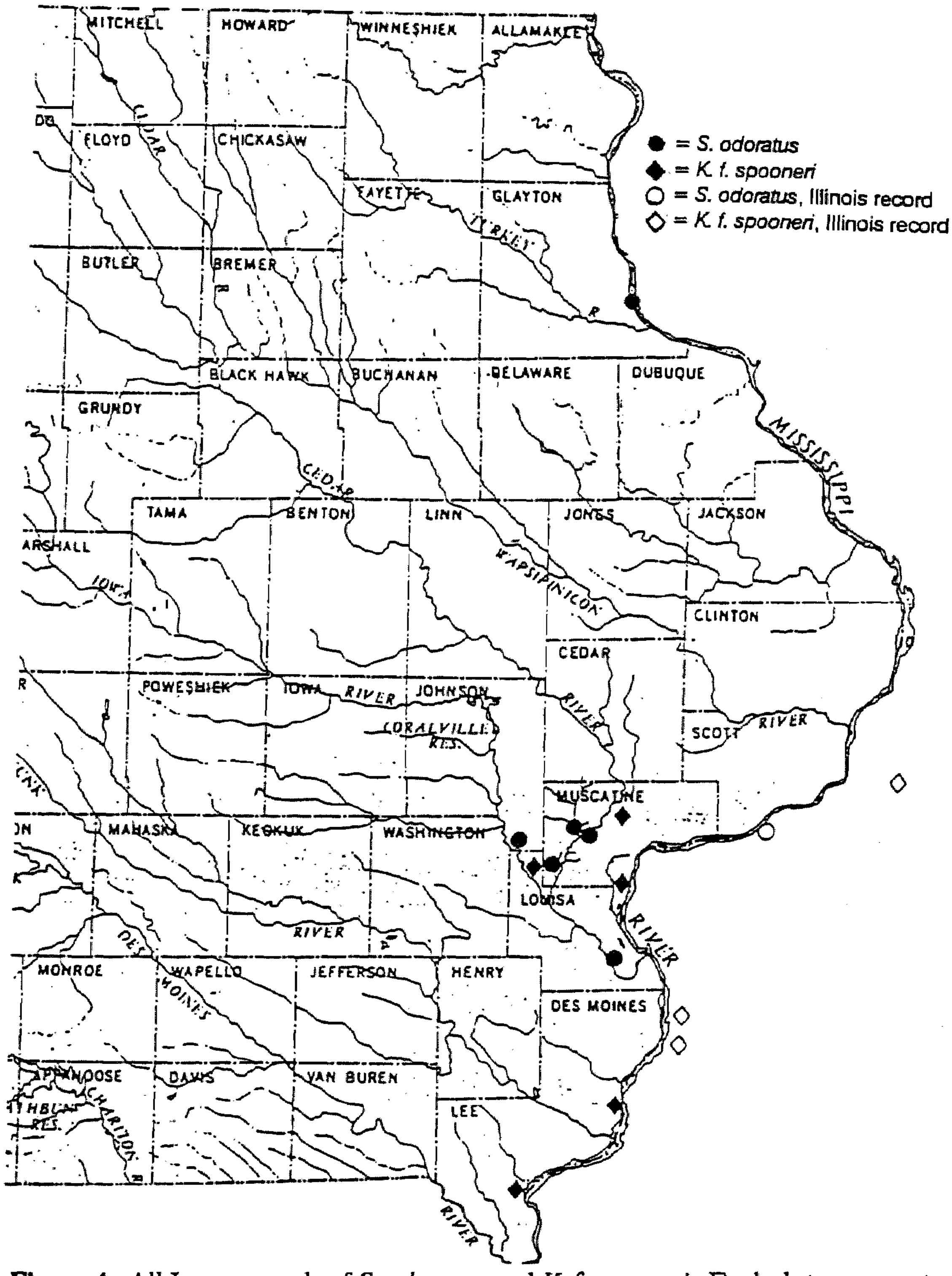


**Figure 4.** All Iowa records of *S. odoratus* and *K. f. spooneri*. Each dot represents a watershed or other complex, and may contain more than one location.

flows through the Cedar River valley in Muscatine county for approximately nine kilometers. Upstream it begins as an intermittent creek, with a few pools that flow together after rainstorms. In its final six kilometers it becomes a wide, highly eutrophic stream with a very slow current. Because the area is prone to flooding by the Cedar River, the surrounding land has not been farmed. Instead it remains a wooded bottomland interspersed with ephemeral pools. The area is characterized by soils that are composed of silty clay loams, or sandy loams with occasional areas of almost pure sand. A sandy ridge borders the area to the west, separating the valley from adjacent higher farmland. Soils of the northern portion of the creek, where it is composed of intermittent pools, are largely poorly drained silty clay loams. The creek flows into Cone Lake, an area 1.2 km long and only seventy-five to one-hundred meters wide. It was formerly traversed by a railroad bridge and is dammed on the south end by a road, forcing the creek to exit through a culvert. From this point, Pike Creek is reduced to a smaller, more rapidly flowing stream until it merges with the Cedar River, two kilometers further south. Our center for operations in this area was one kilometer north of Cone Lake, just north of the Pike Creek bridge. The owner of this property, Robert Goldsberry, was extremely helpful in making his property available to us. Many of the stinkpots, as well as other species present, were encountered on or near his property.

North of the Pike Creek area, still in Muscatine county, the Cedar River valley continues to be bounded on the west by a sandy ridge, below which are swampy areas containing both permanent and ephemeral ponds. The Red Cedar Wildlife Area, owned by the Department of Natural Resources, encompasses both the uplands and bottomlands along the ridge, with long, narrow, shallow sloughs that flow into each other during periods of high precipitation. Sampling extended northward through

Weise Slough, a similar preserve and into Linn County where land adjacent to the Cedar River became less sandy.

The Iowa River flows from northwest to southeast through Louisa county (Fig. 3), and is joined by the Cedar River at Columbus Junction, south of Conesville. Between Columbus Junction and its confluence with the Mississippi, the Iowa is a broad, shallow river. Periods of low water expose many sandbars and mud flats. The floodplain is many kilometers wide in places. Although it is heavily farmed, marshy, bayou-like areas still exist and as many of these were trapped as possible. Soils on this floodplain are also poorly-drained, silty clays or loams, with sandy areas interspersed. In the northwestern corner of the county is the Cone Marsh State Wildlife Management Area, an extensive area of Iowa River floodplain that encompasses several large oxbows, interlaced with swampy areas, surrounded by sandy ridges. This area provided one of the first known mud turtle localities in Iowa (Dodge, 1956). North of the Cone Marsh Wildlife Management Area, in Johnson county, is another large marshy area created by sloughs and oxbows along the Iowa River. The study was not extended northward from that point because of lack of adequately sandy terrain and the presence of the urban area of Iowa City.

# RESULTS

## Distribution of *Sternotherus odoratus* and *Kinosternon flavescens*

*Sternotherus odoratus* is known from 16 localities in Johnson, Louisa and Muscatine counties. Nine of these were discovered during this study (Table 1; Fig. 3). This work extended the known range of the stinkpot in Iowa southward along the Iowa River in Louisa county and north as far as the Red Cedar Wildlife Management Area in Muscatine county (Fig. 3). Pike Creek appears to support the largest stinkpot population. Only one additional locality is known outside this area for the stinkpot. It is in the Mississippi River, at lock and dam number 10, approximately 250 km north of the study area.

Figure 4 depicts the currently known range of both species in the entire state. Note that each dot on the map represents a drainage area rather than a single location. Sampling has been conducted prior to this study in most suitable areas along the Mississippi River and this produced the mud turtle localities shown but yielded no stinkpots (see Bickham et al., 1984).

Over the four year period of this study, no new locations for Illinois mud turtles were discovered in the state, although several areas examined seemed sufficiently sandy to support them. In no instance were stinkpots found in the same bodies of water as Illinois mud turtles. The two species were found within approximately 5 km of each other in northern Muscatine county. The Cone Marsh mud turtle population apparently lacks stinkpots and the Pike Creek stinkpot population, 8 km east (Fig. 3), lacks mud turtles.

A total of 688 turtles were captured during the course of the study. In addition to *K. f. spooneri* and *S. odoratus,* other chelonian species taken include painted turtles

(*Chrysemys picta belli*), snapping turtles (*Chelydra serpentina*), Blanding's turtles (*Emydoidea blandingi*), spiny soft-shelled turtles (*Trionyx spiniferus*) and false map turtles (*Graptemys pseudogeographica*).

Nineteen specimens of *S. odoratus* were encountered from nine separate locations during the four years of trapping (Table 1); 17 specimens were alive while two were represented by shells found on the east side of Pike Creek in April, 1989. Because a drought had struck the area in 1988, followed by an absence of normal spring flooding of the Cedar River, turtles were concentrated in pools. For this reason, 1989 was the most productive trapping season of the study, yielding fifteen specimens.

**Habitats of *K. f. spooneri* and *S. odoratus***

Stinkpots collected from the Pike Creek area are listed in Table 1. Each numbered entry corresponds to its location on the U.S. Geological Survey topographic maps of Figures 5 and 6. These maps depict the Pike Creek area, illustrating the complex of flowing water and discrete ponds that supports the largest number of stinkpots. Numbers following each record denote SCS soil series type. For characteristics of each series, see Table 3. Figure 7 plots all locations shown on Figure 4 in conjuction with the Mississippi Alluvial Plain. Note the close correlation between this area and the range of both species.

**Behavior and life history of *K. f. spooneri* and *S. odoratus***

During the course of the study, only two stinkpots were observed on land. Neither was more than a few meters from water. Stinkpots were never observed basking, either in the water or near it, nor were any of their nests discovered. One of the turtles seen on land was travelling in late June toward Pike Creek from the area of a sandy ridge, possibly she had deposited her eggs there. Stinkpots were captured as early as mid-May in 1989, but no hibernating turtles were ever discovered.

Several mud turtles were observed on land during the study, and over 300 more were captured in a drift fence that was erected at Big Sand Mound as part of another study. Often these were females on their way to nest sites, or turtles moving to or from hibernating/aestivating burrows. Mud turtles were also trapped at Big Sand Mound in the water beginning in late May, 1989. No dietary information was gathered for either species during the study.

**Table 1. Locations, habitats and sympatric species associated with *S. odoratus* in eastern Iowa.**

| Loc. | Habitat | Sympatric species | Soil series |
|---|---|---|---|
| 1 | Pike Creek | - | 315 Aquolls |
| 2 | Pike Creek | - | 315 Aquolls |
| 3 | land, near temporary pond | - | 315 Aquolls |
| 4 | Cone Lake, log jam near shore | *C. serpentina* *C. picta* | 539 Perks sandy loam |
| 5 | Pike Creek, sandy bank | - | 539 Perks sandy loam |
| 6 | Cone Lake, sandy bank | *T. spinifera* *C. picta* | 315 Aquolls |
| 7 | Flooded pool near Pike Creek | *C. picta, T. spinifera* *C. serpentina* | 315 Aquolls |
| 8 | Pike Creek near Cedar River | *C. picta* *C. serpentina* | 133 Colo silty clay loam |
| 9 | driveway along Pike Creek | - | 539 Perks sandy loam |
| 10 | spring-fed pond | *C. serpentina* *C. picta, E. blandingi* | 136 Ankeny sandy loam |
| 11 | spring-fed beaver pond | *E. blandingi, C. picta* *C. serpentina* | 961 Ambraw silt clay loam |
| 12 | dredged slough | *C. picta,* *C. serpentina* | 961 Ambraw silt clay loam |
| 13 | shallow slough, Red Cedar Area | *C. serpentina* *C. picta* | 961 Ambraw silt clay loam |
| 14 | Warnstaff Lake, near Iowa River | *C. picta, T. spinifera* *C. serpentina* | 960 Shafton loam |
| 15 | Ditches, east edge Pike Creek | - | 315 Aquolls |
| 16 | slough near Iowa River, Johnson co. | - | 1539 Coland - Perks Lawson |

**Locations 1 - 12 are shown on figures 5 & 6 (USGS maps).**

**Table 2. Aquatic habitats of *K. f. spooneri* and *S. odoratus*.**

| Water body type | Ephemeral pond | Permanent lentic | Permanent lotic |
|---|---|---|---|
| *K. f. spooneri* | XXXXX | X | X |
| *S. odoratus* | XX | SSSS<br>XX | XXX<br>XXXX |

**Each "X" indicates one location yielding either species. "S" indicates a spring-fed water body.**

Mud turtles were found primarily in ephemeral pools but stinkpots frequented mostly permanent bodies of water (Table 2). The lotic record for mud turtles was for a single turtle observed swimming across a narrow strip of the Mississippi River to an island. The water had only slight current. The permanent lentic record was for a turtle taken from a backwater of the Mississippi River near Fort Madison. Not only were stinkpots taken primarily from permanent bodies of water, but many of those water bodies were spring fed. A body of water was deemed to be temporary if it could be determined, through inquiry of local residents or presence of emergent vegetation, that it had dried up in recent years. Pike Creek is considered to be a permanently flowing body south of County Road G-22 in Muscatine county (Section 9 in Fig. 6).

**Soil series at localities for *K. f. spooneri* and *S. odoratus***

Mud turtles are found almost exlusively where the soil adjacent to their feeding pools is almost pure sand. Stinkpots tend to be limited to water surrounded by more loamy soils (Table 3). Soils from the localities where stinkpots were found were generally alluvial soils typical of river bottoms. Most were poorly drained clay loams, a few were sandy loams.

For comparison, note that snapping turtles, a ubiquitous species, were found with all soil types.

**Table 3. Soil series at trapping locations.**

| Soil series | 41 | 63 | 133 | 136 | 315 | 354 | 539 | 960 | 961 | 1539 |
|---|---|---|---|---|---|---|---|---|---|---|
| *K. f. spooneri* | XX | XXX | | | | X | | | | X |
| *S. odoratus* | | | X | X | XX<br>XX | | XX<br>XX | X | XX<br>XX | X |
| *C. serpentina* | X | XXX | X | XX | XX | X | XX<br>XX | X | XXX | X |

**Each "X" represents a single location.**

Soil series descriptions based on U.S. Department of Agriculture Soil Conservation Service publications (Dankert, 1989; Brown, 1988):

**41 - Sparta sand.** Excessively drained, on stream terraces. Surface and subsurface layers loamy fine sand to .4 to .5 meters. Subsoil- loose sand approximately .75 meters thick.

**63 - Chelsea loamy fine sand.** Excessively drained, on stream terraces. Surface and subsurface layers - loamy fine sand to 1 meter or more, may grade into loose fine sand to 1.5 meters.

**133 - Colo silty clay loam**. Poorly drained, bottom lands. Frequent flooding. Surface and subsurface layers - silty clay loam to 1 meter. Overlays a subsoil of friable silty clay loam to 1.5 meters.

**136 - Ankeny sandy loam.** Well-drained, broad stream terraces. Surface and subsurface layers - sandy loam to .7 meters. Subsoil a friable sandy loam, becoming a friable loamy sand to 1 meter or more.

**315** - **Aquolls.** Poorly drained, bottom lands. Frequent flooding. Surface layer - black silty clay loam to .2 meters, subsurface layer silt loam to .4 meters deeper. The substratum to a depth of about 1.5 meters is sand.

**354** - **Aquolls, ponded** (Louisa county). Very poorly drained, in depressional areas on bottom land adjacent to major streams and benches. Surface layer - friable silty clay loam, loam or clay loam to .3 meters, subsurface - firm, friable silty clay loam, clay loam or sandy loam 1 meter thick. Substratum - clay loam, sandy loam or loamy sand to 1.5 meters.

**539** - **Perks sandy loam.** Excessively drained soil, bottom lands; occasional flooding. Surface and subsurface - sandy loam to .3 meters, underlain with loamy sand for the next .3 meters. Substratum - sand to 1.5 meters.

**960** - **Shafton silt loam.** Poorly drained soil on flood plains along the major rivers. Black silt loam to .3 meters, friable loam for 1 more meter, then loamy sand and sand to a depth of nearly 2 meters.

**961** - **Ambraw silty clay loam**. Poorly drained soil on flood plains along major rivers. Surface and subsurface layers - silty clay loam to .3 meters, substratum - sandy clay loam and sandy loam to 1.5 meters.

**1539** - **Coland-Perks-Lawson** complex (Louisa county). Broad flood plains along large streams and rivers; subject to flooding. Coland soil - poorly drained, clay loam. Perks soil is excessively drained, friable loamy sand with a substratum of sand. Lawson soil is poorly drained silt loam underlain by silty clay loam.

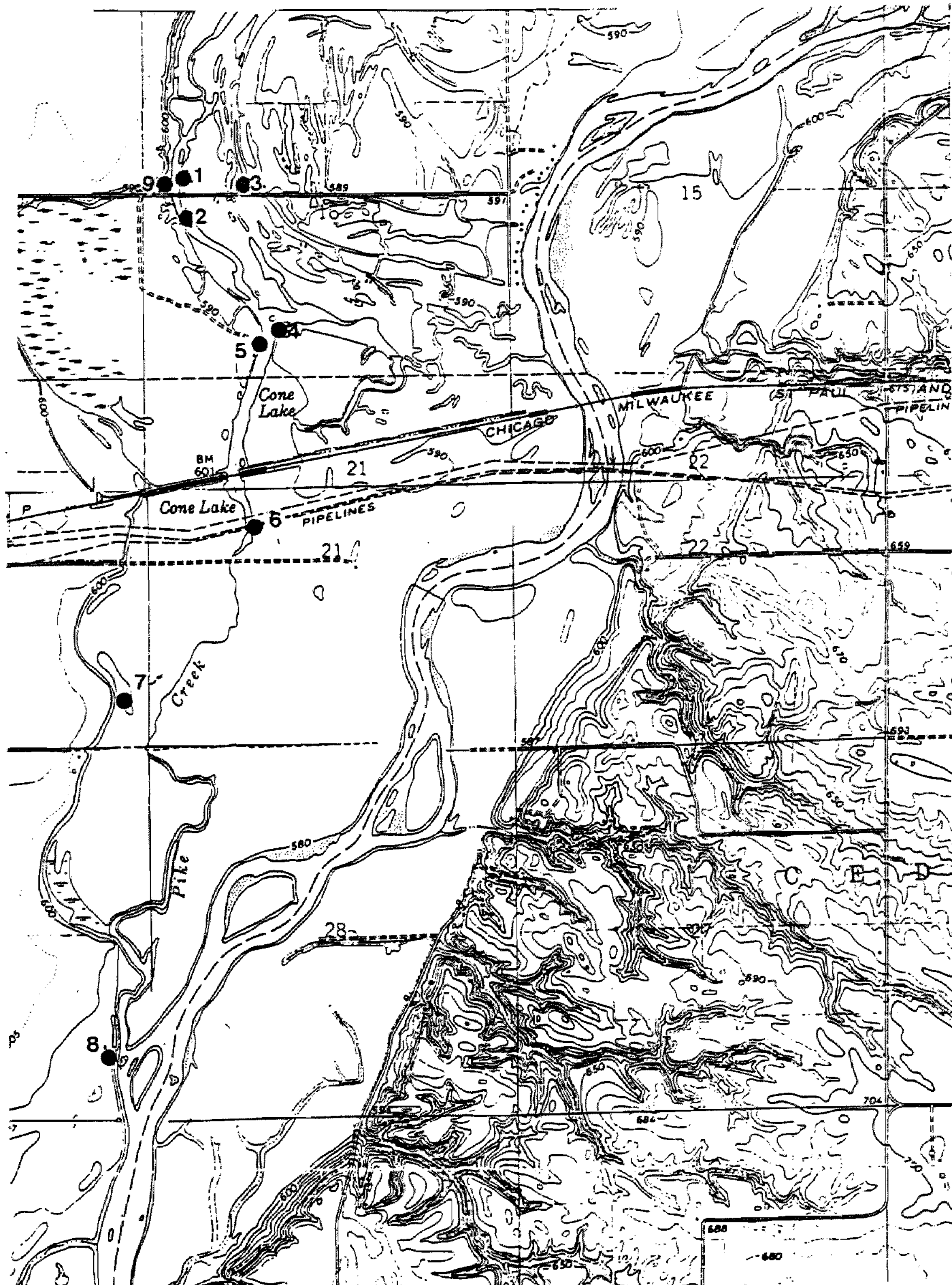


**Figure 5.** Pike Creek drainage, southern portion. Each dot represents one *S. odoratus* location.

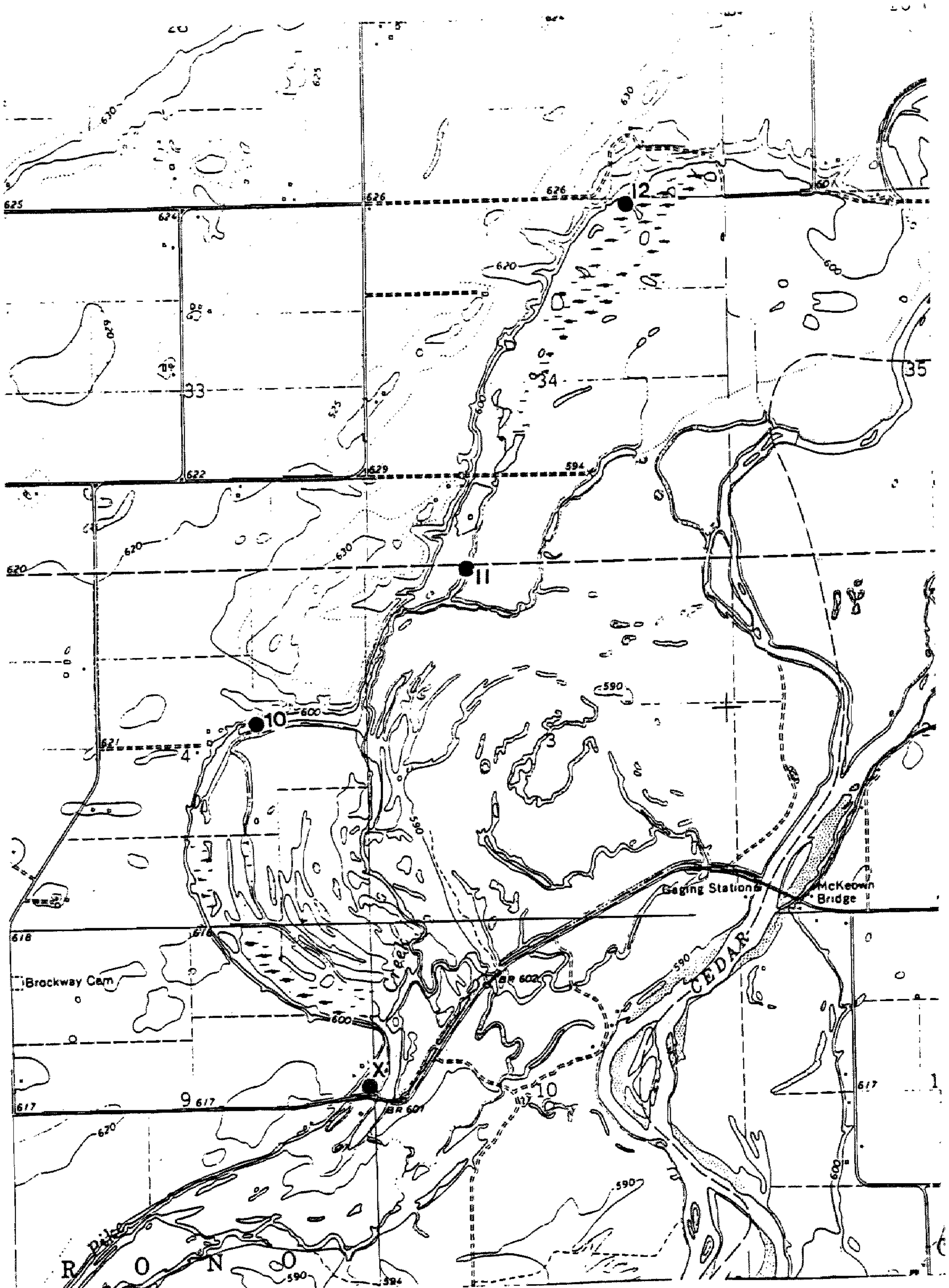


**Figure 6.** Pike Creek drainage, northern portion. Each dot represents one *S. odoratus* location.

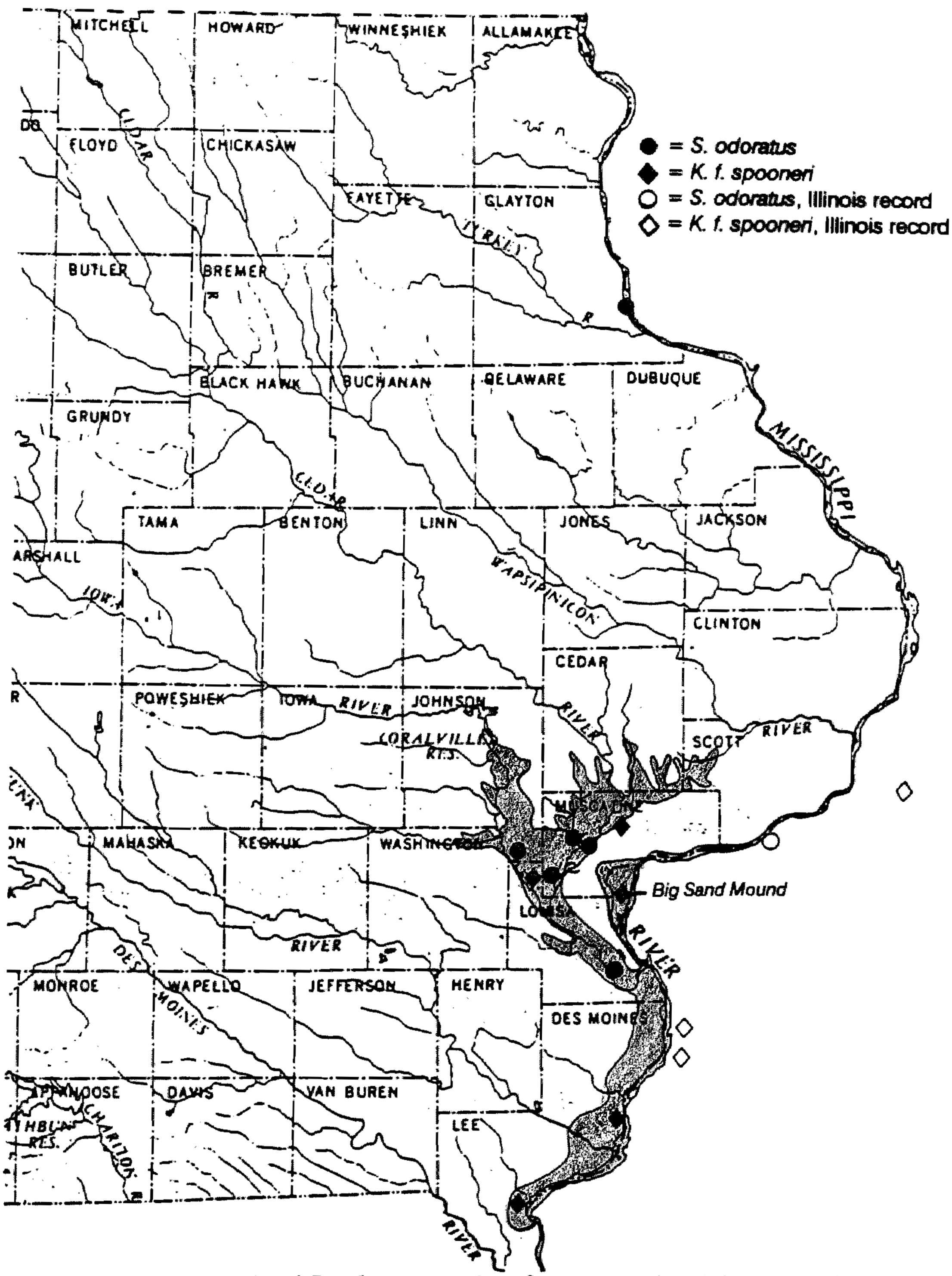


**Figure 7.** Iowa records of *S. odoratus* and *K. f. spooneri* that fall within the Mississippi River Alluvial Plain (shaded area).

# DISCUSSION

## Range extension for *Sternotherus odoratus*

Prior to this study, stinkpots were known from four locations in Iowa; one specimen from the Mississippi River at Clayton county in the northeast, one record from Johnson county along the Iowa River (Dodge, 1956), just north of the Louisa county line, and three specimens from two locations in Muscatine county (Drake University research collection). The Louisa county record of this study expands the known range 35 kilometers to the south of Muscatine county, the Red Cedar record takes it 10 kilometers further north. Overall, the known stinkpot range in Iowa (not including the Clayton county record) consists of a triangular area covering approximately 75 square kilometers. This area is contained entirely within the Mississippi Alluvial Plain (Fig. 7, shaded area). The broad floodplains punctuated with sloughs, oxbows and streams that characterize this landform provide adequate habitat for this highly aquatic turtle. Since this plain extends southward along the Mississippi river into Lee county, it is possible that continued searches there will reveal more stinkpots. For example, the Skunk River, which forms the border between Lee and Des Moines counties, possesses a complex of lakes and sloughs adjacent to its confluence with the Mississippi River, and holds potential for further study.

Neither stinkpots nor Illinois mud turtles are easily caught in traps. It is apparent from trapping records that even in areas where these two species are relatively abundant, they do not seem to enter traps as frequently as other turtles (Bickham et al., 1984). The common snapping turtle (*Chelydra serpentina*) is observed in all aquatic habitats in the area and readily enters turtle traps. Possibly small turtles such as the kinosternids are reluctant to enter a trap containing such a dangerous companion. On three occasions, kinosternids have been kicked up from the mud under the water as researchers were collecting their empty traps. It is possible that small populations of each of these two species exist in areas that have been trapped, but have escaped capture. However, it seems unlikely that large populations would be missed.

The Pike Creek area in Muscatine county, due to its extensive habitat, will probably continue to support the largest population of stinkpots in the state. Although no mark-and-recapture studies were conducted to allow population estimates, stinkpots were found in many individual pools in close proximity to each other. Several stinkpot females from Pike Creek were gravid, but no juveniles were found. Juveniles are commonly missed, possibly due to their small size or dietary preferences.

From the data gathered in during this study, it appears that in Iowa, stinkpots are limited by their need for permanent water, and Illinois mud turtles are limited here by their need for nearly pure sand usually associated with ephemeral ponds. Perhaps for these reasons, these species are not sympatric here. It would appear that ponds adjacent to very sandy areas, unless fed by springs, usually do not contain the necessary permanent water that would make them suitable for stinkpots. One spring-fed pond that occurred adjacent to sandy soil yielded three stinkpots, but no mud turtles. This pond had been dammed by a farmer many years ago, and may have been colonized by immigrating turtles during springtime flooding.

Mahmoud (1969) studied four species of kinosternid turtles in Oklahoma (*Sternotherus odoratus, S. carinatus carinatus, Kinosternon subrubrum hippocrepis,* and *Kinosternon flavescens flavescens*) and found no evidence of overlap in the distibution between *K. flavescens* and the other three species. The yellow mud turtle was restricted to the arid western part of the state; the other species resided in the eastern half.

Smith (1961) shows two Illinois locations for stinkpots that seem to correspond to locations for Illinois mud turtles. Both species have several records from along the Illinois River. A check of these records should determine whether the turtles occupied the same pools. Smith also states that the Illinois mud turtle is found in the sandy areas along the Illinois River, while the stinkpot is found in rivers and small streams, being most abundant in permanent ponds and shallow lakes. Cahn (1937) found stinkpots in Meredosia Bay in the Illinois River, but notes that they avoid large river channels. He states that the Illinois River contained more stinkpots than any other large river in the state. Cahn's description of the Illinois mud turtle as "primarily a pond turtle" would indicate a somewhat different preference for habitats between the two species, which our study seems to support. In Iowa, this preference seems to form a functional barrier to sympatry even where the populations are united by common sandy terrain as occurs in northern Muscatine county.

The highly aquatic nature of the stinkpot has been noted by literally every researcher who has studied it (Cahn, 1937; Smith, 1961; Mahmoud, 1969; Vogt, 1981; Barbour, 1971; Cook, 1984; Ernst, 1986; Gibbons, 1983). There may be physiological reasons for this preference; Ernst (1968) compared evaporative loss of water in *Sternotherus odoratus, Chelydra serpentina, Clemmys guttata, Clemmys insculpta* and *Terrapene ornata*; he found that *S. odoratus* suffered the greatest total weight loss (20%) with a weight-loss rate of 0.24 g / hr. Stinkpots were also the first turtles to show signs of distress upon being removed from water.

Gibbons (1983) studied drought related responses of aquatic turtle populations in South Carolina. The study examined changes in reproduction and emigration as a large (100 ha) bay dried up. Of the species he studied (*Trachemys scripta, T. floridana, Deirochelys reticularia, Kinosternon subrubrum* and *Sternotherus odoratus*), *T. floridana* and *S. odoratus* showed a complete cessation of reproductive activity. The emigration rate for *S. odoratus* did not change from previous years. Gibbons suggests that this response is consistent with their highly aquatic nature; they follow what water remains until it is gone, then burrow into the mud. It does appear that stinkpots will sometimes migrate between water bodies when necessary; Ernst (1986) tracked the movements of several individuals following the draining of their pond. Several males moved up to .70 km to locate new water. Cagle (1944) stated that individuals of *Sternotherus* and *Chelydra* rarely venture onto land except in the early spring, none taken on land had terrestrial food in their stomachs. He decided these movements were associated with "spring wanderlust." He also noted the stinkpots' habit of burying into the mud of drying ponds, rather than emigrating to new ponds.

It is interesting to note that most of the ponds in the Pike Creek drainage that contain stinkpots lie along the base of the ridge that forms the westernmost edge of the Cedar River floodplain. This ridge forms the 600' elevation line on the U.S. Geological Survey maps (Figs. 5 and 6) and is composed of sandy soils that permit rapid percolation of water. The many springs that emerge from the base of this ridge enable the adjacent ponds to retain water permanently while many of the other ponds and sloughs that punctuate the floodplain are ephemeral. They too are often surrounded by soils that contain high percentages of sand (eg. Sparta loamy fine sand; Ankeny sandy loam) but in the absence of a continuous water input, these well-drained soils cannot hold water year-round and thus lack stinkpots. Some stinkpots, including the first specimen discovered in Iowa (Dodge, 1956) were found in watercress laden, cold spring-fed pools (Table 2). The two ephemeral ponds yielding stinkpots were each within 200 meters of Pike Creek, and it is likely that the turtles moved this short distance when the pools dried. Many of the stinkpot records from this study are from

Pike Creek itself, which is a permanently flowing body, with a slow current and high turbidity. Fed by many springs, Pike Creek fits the "ideal habitat" described by many stinkpot researchers (Cahn, 1937; Smith, 1961; Barbour, 1971; Vogt, 1981; Cook, 1984; Ernst, 1986). It has a bottom composed of mud with some gravel and rock, is highly eutrophic, and supports many species of fish and turtles, as well as aquatic invertebrates. The surrounding land is floodplain forest with a few meadows; human impact is far less than on the adjacent uplands. Soils tend to be largely Aquolls (poorly drained bottomland soils), a small percentage are Perks sandy loam.

Pike Creek did not seem to contain suitable sandy habitat for the Illinois mud turtle, and indeed none were found there. Although the Mississippi Alluvial Plain is marked by sandy areas, the dune-type formations that appear to be required by the mud turtle must be close to their aquatic habitat, as at Big Sand Mound. Other dune areas have been stabilized by vegetation or farming, and no longer present proper habitat for these turtles.

With two exceptions, all records for the Illinois mud turtle occur in two types of soil: Sparta sand or Chelsea loamy fine sand (Table 3). These are the sandiest soils classified by the Soil Conservation Service. All bodies of water inhabited by mud turtles in these areas tend to be temporary; all have dried at least once in the past five years. The record for soil #354 (ponded Aquolls) is in Louisa county at Cone Marsh State Management Area near the Iowa River; this is a large complex of wetlands containing sloughs and ponds, many of which are ephemeral. The water from which this turtle is recorded was almost entirely surrounded by Aquolls soil, a poorly drained floodplain soil. Immediately adjacent to this soil zone, however, is a long ridge of Chelsea soil followed by a band of Sparta sand. These sandy bluffs were adjacent to the water on the north side of the pond, which is where the turtle was found. Indeed, the entire uplands surrounding this marsh are a sandy complex. The remaining record on Table 3, #1539 (Coland, Perks, Lawson complex), is a soils complex, typical of floodplains, found on Kilpec Island in the Mississippi River. The turtle in question was observed as it swam from the shore of Big Sand Mound towards the island. It is therefore possible that these two records are not exceptions to mud turtles' requirements for nearly pure sand.

From Table 3 it is apparent that none of the the stinkpot records came from areas as sandy as those of the Illinois mud turtle. Although, as mentioned, a ridge of Chelsea soil runs adjacent to many of the stinkpot ponds, this was not the major soil type for each pond. Generally, soils surrounding stinkpot ponds were more typical of alluvial soils found on river floodplains; some poorly drained, some sandier. No apparent connection could be made between soil type and stinkpot habits; no nests were found that might indicate a nest-site preference. Pond bottoms reflected the surrounding soils and ranged from moderately muddy to very deep mud, with some silted river channels possibly several meters deep.

Aquatic vegetation in ponds inhabited by each species was generally characteristic of the area; some ponds held little vegetation due to high tubidity of the water. *Potamogeton* and filamentous algae were common to most ponds. Some spring-fed areas contained stands of water-cress (*Nasturtium officinale*). Button-bush (*Cephalanthus occidentalis*) and jewelweed (*Impatiens biflora*) were common along the banks of Pike Creek. American lotus (*Nelumbo lutea*) and water lilies (*Nymphaea* spp) were occasionally found in mud turtle ponds.

In general, behaviors of both *K. f. spooneri* and *S. odoratus* seemed consistent with that recorded by other observers. Neither species was observed basking out of water. While mud turtles were found returning to the water after hibernating on land, stinkpots were never seen moving towards water, and it is assumed that in Iowa, as elsewhere, they spend the winter buried in the mud of their pond. Unfortunately, stinkpots were not observed nesting, but the nesting of mud turtles were consistent with those described at Big Sand Mound. Overall, the behavior, like the habitat preferences for the two species are consistent with what is known for these turtles in other areas of the United States, with little, if any, shift occuring as a result of the stresses of life at the extreme edge of their ranges.

# SUMMARY AND CONCLUSIONS

The Illinois mud turtle, *Kinosternon flavescens spooneri*, and the stinkpot turtle, *Sternotherus odoratus*, are two kinosternid turtles that primarily inhabit an area of southeastern Iowa known as the Mississippi Alluvial Plain. They are found in Muscatine, Louisa, Johnson and Clayton counties.

Four years of turtle trapping in southeastern Iowa produced nine new localities for stinkpots in Iowa, but no new locations for Illinois mud turtles. The range of the stinkpot turtle in Iowa has been expanded to an area of approximately 75 square km, excluding the single record for the Mississippi River at Clayton county.

Iowa's peripheral stinkpot and Illinois mud turtle populations are not sympatric but are separated by microhabitat preferences that parallel their separate ecological and evolutionary development. Their niches appear to be consistent with what has been observed much farther south, deep within the species' ranges. The Illinois mud turtle shares its adaptations for xeric habitat with its parent species, the yellow mud turtle of the southwestern U.S. Its need for deep sand for nesting, aestivation and terrestrial overwintering restrict it to a very small area in southeastern Iowa where xeric conditions exist. Although it enters water to feed, it typically spends most of the year in relative dormancy buried in sand on land. The stinkpot evolved in the humid southeastern U.S., and has ranged widely over the eastern U.S. It is extremely aquatic, seldom leaving the water except to lay its eggs. It dessicates rapidly when on land, hibernates in water and utilizes a wide range of nesting sites. Diet for the two species is similar; both species are omnivorous and adaptable. Stinkpots were mostly confined to lotic or permantent lentic bodies of water; soils in these areas were typically alluvial sands, silts and loams. Illinois mud turtles were found more often in ephemeral water, which usually was adjacent to soils of almost pure sand. These differences reflect the habitat where the turtles evolved.

It appears that even at the extremes of their respective ranges, these two species of kinosternid turtles are bound to their heritage, reflecting the conditions that shaped their ancestors. These differences in backgrounds are expressed as genetically determined behaviors that prevent the species from encroaching upon each other, allowing them to occupy adjacent habitats without competing.

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